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(54) **Chlorofluoro elastomer compositions for use in electrophotographic fusing applications**

(57) Elastomer compositions comprising a blend of a fluoroelastomer comprising a terpolymer of vinylidene fluoride, tetrafluoroethylene and hexafluoropropylene and a chlorofluoroelastomer comprising a co-or terpolymer of vinylidene fluoride, chlorotrifluoroethylene and

0-40 mole % of hexafluoropropylene are provided. The composition may be cured and is particularly suitable for use as a surface release layer for fusing systems used in electrostatographic imaging systems.

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Description**BACKGROUND OF THE INVENTION**

Field of the Invention

[0001] The invention relates to blends of chloro/fluoro curable elastomers and their use as release layer coatings for fuser members and transport belts in electrostatographic printing apparatus.

Description of Related Art

[0002] In a typical electrostatographic reproducing apparatus, a light image of an original to be copied is recorded in the form of an electrostatic latent image upon a photosensitive member and the latent image is subsequently rendered visible by the application of electroscopic thermoplastic resin and pigment particles which are commonly referred to as toner. The visible toner image is then in a loose powdered form and can be easily disturbed or destroyed. The toner image is usually fixed or fused upon a support which may be the photosensitive member itself or other support sheet such as plain paper.

[0003] The use of thermal energy for fixing toner images onto a support member is well known. To fuse electroscopic toner material onto a support surface permanently by heat, it is usually necessary to elevate the temperature of the toner material to a point at which the constituents of the toner material coalesce and become tacky. This heating causes the toner to flow to some extent into the fibers or pores of the support member.

[0004] Thereafter, as the toner material cools, solidification of the toner causes the toner to be firmly bonded to the support.

[0005] Typically, the thermoplastic resin particles are fused to the substrate by heating to a temperature of between about 90°C. to about 200°C. or higher depending upon the softening range of the particular resin used in the toner. It is undesirable, however, to increase the temperature of the substrate substantially higher than about 250°C. because of the tendency of the substrate to discolor at such elevated temperatures, particularly when the substrate is paper.

[0006] Several approaches to thermal fusing of electroscopic toner images have been described. These methods include providing the application of heat and pressure substantially concurrently by various means, such as a roll pair maintained in pressure contact, a belt member in pressure contact with a roll, and the like. Heat may be applied by heating one or both of the rolls, plate members or belt members. The fusing of the toner particles takes place when the proper combination of heat, pressure and contact time are provided. The balancing of these parameters to bring about the fusing of the toner particles is well known in the art, and can be adjusted to suit particular machines or process conditions.

[0007] During operation of a fusing system in which heat is applied to cause thermal fusing of the toner particles onto a support, both the toner image and the support are passed through a nip formed between the roll pair or plate or belt members. The concurrent transfer of heat and the application of pressure in the nip affects the fusing of the toner image onto the support. It is important in the fusing process that no offset of the toner particles from the support to the fuser member take place during normal operations. Toner particles that offset onto the fuser member may subsequently transfer to other parts of the machine or onto the support in subsequent copying cycles, thus increasing the background or interfering with the material being copied there. The referred to "hot offset" occurs when the temperature of the toner is increased to a point where the toner particles liquefy and a splitting of the molten toner takes place during the fusing operation with a portion remaining on the fuser member. The hot offset temperature or degradation of the hot offset temperature is a measure of the release property of the fuser roll, and accordingly it is desired to provide a fusing surface which has a low surface energy to provide the necessary release. To ensure and maintain good release properties of the fuser roll, it has become customary to apply release agents to the fuser roll during the fusing operation. Typically, these materials are applied as thin films of, for example, silicone oils to prevent toner offset.

[0008] Fusing systems using fluoroelastomers as surfaces for fuser members are described in U.S. Pat. No. 4,264,181 to Lentz et al., U.S. Pat. No. 4,257,699 to Lentz, and U.S. Pat. No. 4,272,179 to Seanor, all commonly assigned to the assignee of the present invention. The disclosure of each of these patents is hereby incorporated by reference herein in their entirety.

[0009] U.S. Pat. No. 5,017,432 describes a fusing surface layer obtained from a specific fluoroelastomer, poly(vinylidene fluoride-hexafluoropropylene-tetrafluoroethylene) where the vinylidene fluoride is present in an amount of less than 40 weight percent. This patent further discloses curing the fluoroelastomer with VITON® Curative No. 50 (VC-50) available from E. I. Du Pont de Nemours, Inc., which is soluble in a solvent solution of the polymer at low base levels and is readily available at the reactive sites for crosslinking. This patent also discloses use of a metal oxide (such as cupric oxide) in addition to VC-50 for curing.

[0010] U.S. Pat. No. 5,061,965 to Ferguson et al. the disclosure of which is hereby incorporated by reference in its

entirety, discloses an elastomer release agent donor layer comprising poly(vinylidene fluoride-hexafluoropropylene-tetrafluoroethylene) where the vinylidene fluoride is present in an amount less than 40 weight percent and a metal oxide. The release agent donor layer is cured with a nucleophilic curing agent in the presence of an inorganic base.

[0011] Generally, the process for providing the elastomer surface on the fusing system member, e.g., donor roll, pressure roll, fuser roll, toner transfer belt or roller surfaces, and the like, includes forming a solvent solution/dispersion by mixing a fluoroelastomer dissolved in a solvent such as methyl ethyl ketone and methyl isobutyl ketone, a dehydrofluorinating agent such as a base, for example the basic metal oxides. MgO and/or Ca(OH)₂, and a nucleophilic curing agent such as VC-50 which incorporates an accelerator and a crosslinking agent, and coating the solvent solution/dispersion onto the substrate. The surface is then stepwise heat cured.

[0012] Prior to the stepwise heat curing, ball milling is usually performed, for from 2 to 24 hours.

[0013] While these and other fluoroelastomers have proven satisfactory as fuser release surfaces, it is desirable to provide elastomeric materials having even lower surface energy wherein release properties are further enhanced. It is also desirable to provide elastomers as fuser release surfaces possessing improved physical properties, enhanced wear resistance and reduced chemical reactivity with toner resins and additives, paper fibers and other potential contaminants within the fusing subsystem.

SUMMARY OF THE INVENTION

[0014] The present invention provides an elastomer composition comprising a blend of a fluoroelastomer comprising a terpolymer of vinylidene fluoride, tetrafluoroethylene and hexafluoropropylene and a chlorofluoroelastomer comprising a copolymer or terpolymer of vinylidene fluoride, chlorotrifluoroethylene and 0 to about 40 mole percent of one monomer selected from hexafluoropropylene and tetrafluoroethylene; said fluoroelastomer present in said composition at a level of from about 5 to 95% by weight of the elastomer content of said composition.

[0015] The invention also provides a fuser system member used in electrostatographic printing applications wherein a supporting substrate such as a fuser roll or belt contains an outer release layer comprising the cured elastomer composition of the invention.

[0016] The cured composition provides for a lower surface energy coating having enhanced toner release properties thereby reducing the tendency for toner to offset back to the surface of the fuser member during the electrostatographic printing process. The cured composition also exhibits improved wear and physical properties over similar fluoroelastomer compositions currently used in fusing applications.

DETAILED DESCRIPTION OF THE INVENTION

[0017] Suitable fluoroelastomers which provide the fluoroelastomeric component of this invention are perfluororubbers of the polymethylene type having all substituent groups on the polymer chain either fluoro, perfluoroalkyl or perfluoroalkoxy groups, and wherein the polymer is free of other halogen substituents such as chlorine groups.

[0018] The fluoroelastomers useful in the practice of the present invention are those described in detail in U.S. Pat. No. 4,257,699 to Lentz, as well as those described in commonly assigned U.S. Pat. Nos. 5,017,432 to Eddy et al. and 5,061,965 to Ferguson et al. As described therein, these fluoroelastomers, particularly from the class of copolymers, terpolymers, and tetrapolymers of vinylidene fluoride, hexafluoropropylene, tetrafluoroethylene, and cure site monomer (believed to contain bromine) are known commercially under various designations such as Viton A, Viton E60C, Viton E430, Viton 910, Viton GH, Viton GF and Viton F601C. The Viton designation is a Trademark of E.I. DuPont de Nemours, Inc. Other commercially available materials include Fluorol 2170, Fluorol 2174, Fluorol 2176, Fluorol 2177 and Fluorol LVS 76, Fluorol being a Trademark of 3M Company.

[0019] Additional commercially available materials include Aflas poly(propylene-tetrafluoroethylene) copolymer, Fluorel II, a poly(propylene-tetrafluoroethylene-vinylidene fluoride) terpolymer both also available from 3M Company. Typically, these fluoroelastomers can be cured with a nucleophilic additive curing system, such as a bisphenol crosslinking agent with an organophosphonium salt accelerator as described in further detail in the above referenced Lentz Patent and in the Eddy et al. patent or with a peroxide in which case a cure site monomer such as bromomethyl perfluorovinyl ether is also necessary.

[0020] A particularly preferred embodiment of the hydrofluoroelastomer is that described in U.S. Pat. No. 5,017,432 to Eddy et al. which provides a fuser member surface layer comprising poly(vinylidene fluoride-hexafluoropropylene-tetrafluoroethylene-cure site monomer (believed to contain bromine) wherein the vinylidene fluoride is present in an amount less than 40 weight percent and which is cured from a dried solvent solution thereof with a nucleophilic curing agent soluble in the solvent solution and in the presence of less than 4 parts by weight inorganic base per 100 parts of polymer, the inorganic base being effective to at least partially dehydrofluorinate the vinylidene fluoride. These materials are described in greater detail in U.S. Pat. No. 5,017,432. The nucleophilic curing system is further described in greater detail in U.S. Pat. No. 4,272,179 to Seanor and U.S. Pat. No. 4,264,101 to Lentz et al.

[0021] The chlorofluoro elastomers which provide the chlorofluoroelastomeric component of this invention include co- and terpolymers comprising vinylidene fluoride, chlorotrifluoroethylene and from 0 to about 40 mole percent of at least one monomer selected from hexafluoropropylene and tetrafluoroethylene. These are analogous to the fluoroelastomers described above except that they contain some chloro substituent groups which tend to enhance the solubility of these polymers in organic solvent and further facilitate co-crosslinking with the fluoroelastomer component of the blend. Suitable chlorofluoroelastomers include copolymers of vinylidene fluoride with chlorotrifluoroethylene and terpolymers comprising the above two monomers with up to 40 mole percent of hexafluoropropylene or tetrafluoroethylene. Preferred copolymers contain from about 20 to 40 mole % vinylidene fluoride and correspondingly from about 60 to 80 mole % chlorotrifluoroethylene; preferred terpolymers contain from about 15 to 25 mole % vinylidene fluoride from about 35 to 84 mole % chlorotrifluoroethylene and from about 1 up to 40 mole % of either hexafluoropropylene or tetrafluoroethylene.

[0022] Chlorofluoroelastomers particularly suitable for use in the invention are more specifically described in U.S. Patents 3,988,502 and 4,032,699, the complete disclosure of which patents are incorporated herein by reference.

[0023] These elastomers may be blended in a ratio such that either elastomer comprises from about 5 to 95 wt% of the elastomeric content of the composition. Preferably the fluoroelastomer will constitute at least 50 wt% of the elastomer content of the composition.

[0024] The fluoro and chlorofluoro elastomer blend may be cocured (covulcanized) using any of the nucleophilic, free radical or amine curing systems which are well known in the art for curing fluoroelastomers. Nucleophilic curing systems may include a bisphenol crosslinking agent and an organophosphonium salt accelerator. Typically, the curing process takes place in the presence of 8 to 10 parts by weight of inorganic base per 100 parts of polymer. The inorganic base dehydrofluorinates the vinylidenefluoride in the polymer creating double bonds which act as reactive sites for crosslinking. However, the presence of excess base results in the long term degradation of the elastomers and if excess base continues to dehydrofluorinate the vinylidenefluoride generating double bonds which cause the toner member to harden, subsequent oxidation causes the surface energy to increase and the release performance to degrade. Thus, it is preferred to cure the polymer at a relatively low base level to control the reactivity of the vinylidenefluoride.

[0025] A typical nucleophilic curing system is disclosed in U.S. Patent 4,272,179, the complete disclosure of which is incorporated herein by reference.

[0026] Other curatives which can be employed include peroxides, hydrides, bases, oxides, amines and the like. Examples of strong nucleophilic agents include primary, secondary and tertiary aliphatic and aromatic amines, as well as amino silanes such as disclosed in U.S. Patents 5,700,568 and 5,729,813, the complete disclosure of which patents are incorporated herein by reference.

[0027] Other adjuvants and fillers may be incorporated in the elastomer composition in accordance with the present invention provided that they do not adversely effect the integrity of the fluoroelastomer. Such fillers normally encountered in the compounding of elastomers include coloring agents, reinforcing fillers such as carbon black and silica, and processing aids. Also: Aluminum oxide, indium tin oxide, antimony tin oxide, silicon carbide, zinc oxide and boron nitride may be included as fillers, which may be present at a level of from about 1-20 volume percent. Oxides such as copper oxides may be added in certain amounts such as, for example, from about 1 to about 10 volume percent, to fuser roll coatings to provide sufficient anchoring sites for functional release oils and thereby allow excellent toner release characteristics from such members. Fillers may optionally be pre-treated or treated in solution with silane coupling agents to improve filler incorporation into the polymer network.

[0028] The substrate for the fuser member of the fuser system assembly may be a roll, belt, flat surface or other suitable shape used in the fixing of thermoplastic toner images to a suitable substrate. It may take the form of a fuser member, a pressure member or a release agent donor member, preferably in the form of a cylindrical roll. Typically, the substrate takes the form of a cylindrical tube of aluminum, copper, steel or certain plastic materials chosen to maintain rigidity and structural integrity as well as being capable of having the elastomer coated thereon and adhered firmly thereto. The diameter of the substrate is from about 10 to about 100 mm, and preferably from about 40 to about 75 mm. It is preferred that the supporting substrate is a cylindrical sleeve having an outer layer of from about 1 to about 6 mm. In one embodiment, the core, which may be a steel cylinder is degreased with a solvent and cleansed with an abrasive cleaner prior to being primed with a primer, such as Dow Corning 1200, which may be sprayed, brushed or dipped, followed by air drying under ambient conditions for thirty minutes and then baked at 150° C for 30 minutes.

[0029] The outer layer of the fuser member is preferably prepared by dissolving the elastomer in a typical solvent such as methyl ethyl ketone, methyl isobutyl ketone and the like. A nucleophilic dehydrofluorinating agent is then added followed by stirring for 1 to 60 minutes at 45° to 85° C. The resulting solution is then used to fabricate the outer layer of a fuser member by conventional solution coating methods, spraying, dipping, flow coating, or the like. The coating thickness can vary depending upon specific applications from about 10 to about 250 micrometers thick. The coating is first air dried and then step heat cured in air. For fuser applications, the thickness of the dry fluoroelastomer layer could be any suitable thickness, for example, from 25 to about 75 and preferably from about 35 to about 50 micrometers. This thickness range is selected to provide a layer thin enough to prevent a large thermal barrier for fusing and thickness

enough to allow a reasonable wear life. While molding, extruding and wrapping techniques are alternative means which may be used, it is preferred to spray or flow-coat successive applications of the solvent solution. When the desired thickness of coating is obtained, the coating is cured and thereby bonded to the roll surface.

[0030] The curing time, is for example, from about 30 minutes to about 24 hours and the preferred time is from about 1 to 4 hours, and particularly preferred is from about 1 to about 2 hours. The temperature for curing is from about 100° to about 150° C., and preferably from about 130° to about 150° C.

[0031] The following example is illustrative of the invention. As used in the example, FK-800 is a copolymer of chlorotrifluoroethylene and vinylidene fluoride containing about 74 wt% chlorotrifluoroethylene (available from 3M or Mach 1, Inc. King of Prussia, PA) and Viton GF is a terpolymer of 35 wt% vinylidene fluoride, 34 wt% hexafluoropropylene and 29 wt% tetrafluoroethylene available from Dupont.

Example 1

[0032] Several 20% solids solution comprising varying weight percentages of FK-800 and Viton GF in methyl isobutyl ketone was prepared. An appropriate amount of an aminosilane, aminoethyl-aminopropyl trimethoxysilane (AO700, available from United Chemical Technologies), was added to each solution to provide a cured composition possessing a similar crosslink density value, i.e. approximately 1×10^{-4} moles of chains per cubic centimeter as measured by the Flory-Rehner equation. This solution along with identical control solutions containing only Viton GF as the elastomer components were placed in a small glass dish and allowed to desolvate. The resulting films were then soaked overnight in methylethyl ketone with no apparent solubilizing which indicated a crosslinked matrix. The Test films were submitted for physical properties. Data and more information on the compositions is in Table 1

Table 1 -

Table of Tested Films, Properties				
Composition I.D.	1	2	3	4
Wt. Percent FK-800	100	85	70	55
Wt. Percent Viton GF	0	15	30	45
AO700, pph	5	7	8	9
Tensile Strength, PSI	1265	1325	1704	1572
Elongation, %	382	242	308	204
Toughness, in-lb/in ³	2004	1707	2954	2094
Initial Modulus, PSI	630	1479	2183	3847
Release Strength, oz./in-width	18.3	12.9	11.8	9.1
Abrasion Resistance, mg.loss/500 cycles	59.2	77.5	73.3	NT (not tested)

[0033] It should be noted that the physical properties are more plastic-like with addition of FK-800, as the initial modulus increased. The other properties important for fusing materials increase as well, while maintaining a comparable elongation (percent strain at break) as compared to the control material, Viton GF 100%.

[0034] It should be understood that the foregoing description is only illustrative of the invention. Various alternatives and modifications can be devised by those skilled in the art without departing from the invention. Accordingly, the present invention is intended to embrace all such alternatives, modifications and variances which fall within the scope of the appended claims.

Claims

1. An elastomer composition comprising a blend of:

a) a fluoroelastomer comprising a terpolymer of vinylidene fluoride, tetrafluoroethylene and hexafluoropropylene; and

b) a chlorofluoroelastomer comprising a copolymer or terpolymer of vinylidene fluoride, chlorotrifluoroethylene and 0 to about 40 mole percent of a monomer selected from the group consisting of hexafluoropropylene and

tetrafluoroethylene;

said fluoroelastomer present in said composition at a level of from about 5 to 95% by weight of the elastomer content of said composition.

- 5 **2.** The composition of claim 1 wherein said fluoroelastomer is present in said composition at a level of at least about 50% by weight of the elastomer content of said composition.
- 10 **3.** The composition of claim 1 wherein said blend is cured.
- 15 **4.** A fuser system member comprising a supporting substrate and an outer surface layer comprising the cured blend of claim 3.
- 5.** The fuser system of claim 4 wherein the supporting substrate is a fuser roll, a pressure roll or a release agent donor roll.
- 6.** The fuser system of claim 4 wherein the supporting substrate is a cylindrical sleeve, a drum or a belt.
- 20 **7.** The fuser system of claim 4 wherein said outer surface layer has a thickness of about 10 to 250 micrometers.
- 8.** The composition of claim 1 further including a filler material.
- 9.** The composition of claim 8 wherein said filler is treated with a silane coupling agent.



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 02 00 2199

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